

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE  
PATENT APPLICATION  
for

**MAGNETIZING FIXTURE WITH INSULATED CORE**

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## **Magnetizing Fixture with Insulated Core**

### **Technical Field**

The present invention relates to a magnetizing fixture, and more particularly, to a  
5 magnetizing fixture of motor magnets.

### **Background Art**

Magnets are employed in a variety of appliances where the application often dictates the physical shape of the magnet and the pattern of magnetization. For example, the rotor of  
10 a DC motor incorporates a magnet in the shape of a hollow cylinder where the magnetization is generally radial, that is, perpendicular to the cylindrical walls. Although it is possible to construct various magnet shapes from several standard sized and shaped magnets, it is often preferable to achieve the desired magnetization with a single object having the desired shape.

During magnetization, an object to be permanently magnetized is placed in a region  
15 having a magnetic field with a particular configuration. To that end, such a magnetic field often is generated with a magnetizing system. One type of magnetizing system includes a magnetizer that supplies electrical current to a coupled magnetizing fixture. The fixture typically has an electrically conductive, non-permanently magnetizeable core of substantial magnetic permeability to concentrate and focus the magnetic fields produced by current  
20 flowing through a plurality of surrounding conductors. To begin magnetization, magnetizeable material to be permanently magnetized, e.g., steel, may be placed around or about the magnetizing fixture. The magnetizing system then generates a magnetic field to magnetize the material.

Proper configuration of the magnetic fields requires that electrical current flow only  
25 through the electrical conductors. Undesirably, because of contact between the conductors and the core, current often is diverted into the steel core. Current flowing through the core thus distorts both the resulting magnetic fields and, consequently, the subsequent permanent magnetization of the object being magnetized.

### **Summary of the Invention**

In accordance with one aspect of the invention, a magnetizing fixture is provided for connection to an electrical power supply. The magnetizing fixture has an electrically conductive structure with an electrically conductive top and several electrically conductive elements, the first ends connected to a power supply and the second ends to the electrically conductive top. An electrically conductive core of substantial magnetic permeability has a top surface coupled to the electrically conductive top and channels communicating from the top surface to the bottom surface of the core. Each electrically conductive element is contained in a channel. The top and bottom surfaces of the electrically conductive core and the channels are coated with an electrically insulating layer.

In accordance with an embodiment of the invention, the channels may be open and may completely contain the electrically conductive elements laterally.

In accordance with an additional embodiment of the invention, the insulating layer may contain several sublayers. In an embodiment where the insulating layer contains two sublayers, the first sublayer may contain nickel, chromium, and yttrium and the second may contain stabilized zirconia.

In accordance with a further embodiment of the invention, adjacent electrically conductive elements may be connected to different electrical connections.

In accordance with another aspect of the invention, a method is provided for constructing a magnetizing fixture. An electrically conductive structure that forms an interior and an electrically conductive core of substantial magnetic permeability are provided. After coating a part of the electrically conductive core with an electrically insulating material, the insulated core is secured within the interior of the conductive structure. Securing may be done by soldering the conductive structure to another structure, where the melting temperature of the electrically insulating material exceeds the soldering temperature.

In accordance with a further embodiment of the invention, channels may be formed in the electrically conductive core between a top and a bottom surface and the channels and top and bottom surfaces may be coated with the electrically insulating material. The electrically insulating material may include a first layer of nickel, chromium, aluminum, and yttrium, and a second layer of stabilized zirconia.

In accordance with a further aspect of the invention, a magnetizing fixture is provided with an electrically conductive element capable of receiving power from a power source, an electrically conductive core of substantial magnetic permeability positioned within the conductive element, and an insulator that prevents electrical contact between at least a  
5 portion of the conductive element and the conductive core.

In accordance with still another embodiment of the invention, an insulator may coat the conductive core.

In accordance with a still further embodiment of the invention, the conductive element may include legs electrically connected with a power source terminal. Each leg may  
10 have a first end and a second end, where the second ends of the legs may be connected together and each first end may be connected to a positive or negative power source terminal.

In accordance with a still additional embodiment of the invention, a connection material may connect a bar connected to a power supply port with the conductive element. The connection material may have a melting point less than the melting point of the  
15 insulator. The connection material may be a solder and, in certain embodiments, may be a silver solder.

### **Brief Description of the Drawings**

The foregoing features of the invention will be more readily understood by reference to the following detailed description, taken with reference to the accompanying drawings, in  
20 which:

Fig. 1 shows an illustrative magnetizing system that can incorporate various embodiments of the invention.

Fig. 2 shows schematically an embodiment of a magnetizing fixture.

Fig. 3A is a schematic top view, Fig. 3B a schematic front view, Fig. 2C a schematic  
25 side view, and Fig. 2D a schematic cross-sectional view of the magnetizing fixture shown in Fig. 2.

Fig. 4A shows schematically an embodiment of an electrically conductive structure as incorporated in the magnetizing fixture shown in Fig. 2. Fig 4B is a schematic side view and Fig 4C a schematic top view of the electrically conductive structure.

Fig. 5A shows schematically an embodiment of electrical connections as incorporated in the magnetizing fixture shown in Fig. 2. Fig. 5B and Fig. 5C are schematic top and front views respectively of the electrical connection. Fig. 5D and Fig. 5E are schematic front and side cross-sectional views respectively of the electrical connection.

5 Fig. 6A shows schematically an electrically conductive core of substantial magnetic permeability. Fig. 6B is a schematic top view of the core. Fig. 6C and Fig. 6D are schematic front and side cross-sectional views respectively of the core.

Fig. 7 shows a process for making an embodiment of the magnetizing fixture.

### **Detailed Description of Specific Embodiments**

10 Magnets are central to the operation of many motor-driven appliances. In the case of ordinary DC or brushless DC electric fans, rotating magnetic fields created by sequential excitation of electrical currents in stator windings interact with magnets located on a rotor to provide torque to rotate the rotor in a desired manner. The magnetic field established by the stator is designed to interact with the magnetic field established by the rotor magnets. For  
15 example, in single phase excitation, if the rotor contains six magnetic poles of particular angular width and distribution, the stator has a similar number and arrangement of magnetic poles. In the case of three phase excitation, there may be nine or more poles.

It is advantageous to construct the rotor magnet by magnetizing a single object of magnetizable material rather than from assembly of individual magnets. Among other  
20 reasons, assembly is simpler and more accurate. However, the advantages depend on the reliable magnetization of the rotor magnet.

Magnetization takes place when the object to be magnetized is positioned in the vicinity of magnetic fields that are consistent with the geometry of the object and the required magnetization pattern. For a cylindrical rotor magnet, the desired magnetization is  
25 radial in direction (i.e., through the thickness of the magnet) with equal numbers of north and south poles.

Magnetic fields generated by electrical currents flowing through conductors lack the focus required for effective magnetization of the object. Placement of conductors near suitably shaped magnetic material of substantial magnetic permeability may properly  
30 concentrate magnetic fields if no air gaps are present between the conductors and the shaped

magnetic material. A magnetic material, such as cold rolled steel, possessing a magnetic permeability relative to the magnetic permeability free space of more than about 100 has substantial magnetic permeability. To preserve electrical isolation in the absence of physical isolation, various embodiments of the invention provide an electrically insulating material to  
 5 separate the conductors and the shaped magnetic material.

Fig. 1 shows a magnetizing system **100** that may incorporate illustrative embodiments of the invention. The magnetizing system includes a magnetizer **110** that applies electrical current to an attached magnetizing fixture **120**. In illustrative  
 10 embodiments, a magnetizable object **130** is slipped over the outer surface **125** of fixture **120**. Once the object **130** is in place, the magnetizer **110** delivers current to the fixture **120**, thus producing a magnetic field. This magnetic field consequently permanently magnetizes the magnetizable object **130**. Details of the interaction between the magnetizer **110** and the magnetizing fixture **120** are discussed below.

Fig. 2 schematically shows an embodiment of the magnetizing fixture **120** according  
 15 to the present invention. The fixture includes an electrically conductive structure **210** surrounding an electrically conductive, non-permanently magnetizeable core **220** of substantial magnetic permeability. The electrically conductive structure **210** has an electrically conductive top **212** attached to second ends of a plurality of electrically  
 20 conductive elements or legs **213-218** (**213** and **218** are shown in Fig. 4) extending therefrom. First ends, i.e., ends opposite from the top **212**, (e.g., **219**) of the electrically conductive elements **213-218** alternately couple to either a first electrical connection **230** or a second electrical connection **240**. Thus, if a positive voltage source is coupled to the first electrical  
 25 connection **230** and a negative voltage source is coupled to the second electrical connection **240**, current flows away from the first electrical connection **230**, through electrically conductive elements **213**, **215**, and **217**, and through electrically conductive top **210** before returning to the second electrical connection **240** (through electrically conductive elements **214**, **216**, and **218**.)

To further illustrate the magnetizing fixture **120**, Figs. 3A-3D schematically show top, front, side, and cross-sectional views of the magnetizing fixture **120**, which also includes  
 30 an electrically insulating block spacer **250** that may be comprised of BAKELITE (phenol formaldehyde or phenolic) and electrically separates electrical connections **230** and **240**.

The core **220** alters the configuration of magnetic fields generated by electrical currents flowing through the electrically conductive structure **210**. In particular, because the core **220** has substantial magnetic permeability, the core **220** alters the magnetic fields in regions external to the core **220** in which the object **130** is immersed to establish desired magnetization in the object **130**. Establishment of proper magnetization requires  
 5 confinement of electrical currents to the electrically conductive structure **210**. Without confinement of the electrical current, the object **130** is exposed to magnetic fields of improper strength and variation.

However, efficient production of magnetic fields by electrical currents requires close  
 10 proximity of the core **220** and the electrically conductive structure **210**. In fact, since effective magnetization often requires minimal space between the magnetizing fixture **120** and the object **130**, the electrically conductive structure **210** must often be embedded in the core **220**. Should the core **220** be comprised of an electrically conductive material, such as steel, contact between the core **220** and the electrically conductive structure **210** causes  
 15 electrical current to leak from the electrically conductive structure **210** and distort the magnetization of the object **130**. To overcome this problem, aspects of the invention confine electrical currents within the magnetizing fixture **120** to the electrically conductive structure **210** so as to produce a magnet with desired magnetization. Specifically, aspects of the invention provide an insulator **640** (see Fig. 6) between the conductive structure **210** and the  
 20 core **220**.

Fig. 4A-4C schematically shows an embodiment of the conductive structure **210**, which may be comprised of copper. The electrically conductive elements **213-218** may have a rectangular cross-section and be perpendicular to the electrically conductive top **212**, integrally coupling to the electrically conductive top **212** via second ends (e.g., **211**). The  
 25 electrically conductive elements **213-218** may be distributed at equal angular intervals about a circumference of the electrically conductive top **212**. Of course, discussion of six electrically conductive elements **213-218** is exemplary and thus not intended to limit the scope of the invention.

Fig. 5A-5E schematically show embodiments of the first and second electrical  
 30 connections or bars **230** and **240**, which may be comprised of copper. The second electrical connection **240** contains a source connector **510** and a suspended connector **522**. The source

connector **510** may contain a receptacle **512** to receive the electrically conductive element **217** and a receptacle **514** to receive the electrically conductive element **215**. The suspended connector **520** may contain a receptacle **522** to receive the electrically conductive element **213**. Likewise, the first electrical connection **230** contains a source connector **560** with  
 5 receptacles **562** and **564** that may receive the electrically conductive elements **218** and **214** and a suspended connector **570** with a receptacle **572** that may receive the electrically conductive element **216**.

Fig. 6 schematically illustrates the electrically conductive core **220**, which may be comprised of steel. The electrically conductive core **220** contains a top surface **620**, a bottom  
 10 surface **630**, and channels **613-618** in a side surface **655** coated with an electrically insulating layer **640**. The channels **613-618** are open at the top surface **620**, at the bottom surface **630**, and along the side surface **655**. In some embodiments, the insulating layer **640** comprises an outer or second sublayer **642** and an inner or first sublayer **644**. The outer sublayer **642** may contain stabilized zirconia. The inner sublayer **644** may contain a combination of nickel,  
 15 chromium, aluminum, and yttrium.

Process **700** for making the magnetizing fixture **120** is summarized in Fig. 7. In Step **710**, the electrically conductive core **220**, the electrically conductive structure **210**, the electrical connections **230** and **240**, and electrically insulating block spacer **250** may be made, for example, by machining or molding the core **220** from steel, the conductive  
 20 structure **210** and electrical connections **230** and **240** from copper, and the block spacer **250** from BAKELITE (or another electrically insulating material).

In Step **720**, the core **220** is selectively masked to cover the outer surface **650** and to leave uncovered the top surface **620**, the bottom surface **630**, and the channels **613-618**. Masking may be accomplished by coating the core with photoresist, exposing the top surface  
 25 **620**, the bottom surface **630**, and the channels **613-618** to ultraviolet radiation to cure the photoresist in those areas. and dissolving away unexposed photoresist.

In Step **730**, the core **220** is coated with the inner sublayer **644**, by spraying and baking a coating containing a combination of nickel, chromium, aluminum, and yttrium, and in Step **740** with the outer sublayer **642**, possibly stabilized zirconia. In Step **750**, the outer  
 30 surface **650** is unmasked, e.g., by dissolving away the exposed photoresist.

In Step **750**, the electrically conductive structure **210** couples to the coated core **220**. For a conductive structure **210** with elements **213-218** extending from a conductive top **212** and a coated core **220** with channels oriented parallel to the side **655** of the coated core **220**, the conductive top **212** may set on top surface **520** of the coated core **220** and the elements  
 5 **213-218** may lie flush with or be laterally confined, i.e., lying entirely beneath the outer surface **650** of the coated core **220**. As a result, adjacent electrically conductive elements, e.g. **217** and **218**, are connected to receptacles of different electrical connections.

In Step **760**, receptacles **512**, **514**, and **522** of the second electrical connection **240** receive electrically conductive elements **217**, **215**, and **213**. In Step **770**, receptacles **563**,  
 10 **564**, and **584** of the first electrical connection **230** receive the electrically conductive elements **218**, **214**, and **216**.

In Step **780**, electrically conductive elements **217**, **215**, and **213** are silver soldered at a temperature above the melting point of silver solder and below the melting points of copper, steel, zirconia, and a combination of nickel, chromium, aluminum, and yttrium to  
 15 receptacles **512**, **514**, and **522** and, in Step **790**, electrically conductive elements **218**, **214**, and **216** are similarly silver soldered to receptacles **563**, **564**, and **584** at the electrically conductive element-receptacle joints (e.g. **205**).

To solder, the temperature of the magnetizing fixture **120** is raised to about 800 °C and a small torch is used to locally heat the electrically conductive element-receptacle joints  
 20 to a temperature above about 940 °C and less than about 1085 °C. Since copper melts at about 1085 °C, steel at about 1370 °C, zirconia at about 2700 °C, and Ni-Cr-Al-Y at about 1138 °C, and silver solder at about 940 °C, soldering does not affect either the core **220**, the conductive structure **210**, the inner sublayer **644**, or the outer sublayer **642**.

In Step **790**, the block spacer **250** is mounted to separate electrical connections **230**  
 25 and **240**.

The described embodiments of the invention are intended to be merely exemplary and numerous variations and modifications will be apparent to those skilled in the art. All such variations and modifications are intended to be within the scope of the present invention as defined in the appended claims.